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VOL. XV. NO. 7. 19TH JAN., 1922.

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TRANSACTIONS

OF

THE ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE

London:
ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE,
11, CHANDOS STREET, CAVENDISH SQUARE, W. 1.

PRICE FIVE SHILLINGS NET.

(For Publishing Notices see page iii. of cover.)

ISSUED MARCH, 1922.

TRANSACTIONS OF THE
ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE.

JANUARY, 1922. VOLUME XV. No. 7.

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TRANSACTIONS
OF THE
ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE.

JANUARY 19TH, 1922.

VOLUME XV. No. 7.

Proceedings of a meeting of the Society held on Thursday, 19th January, 1922, at 8.15 p.m., at 11, Chandos Street, Cavendish Square, W. 1, preceded by a Demonstration at 7.45 p.m. on "Some Stages in the Development of *Trypanosoma lewisi* of the Rat, by Dr. A. C. STEVENSON.

Sir JAMES CANTLIE, K.B.E., F.R.C.S. *(President)*, in the Chair.

SOME RELATIONS BETWEEN VEGETABLE AND HUMAN PATHOLOGY.

BY

E. J. BUTLER, C.I.E., M.B., *Director of the Imperial Bureau of Mycology.*

The differences in the organisation of the higher plants and animals are such—especially in the absence of true circulatory, nervous and digestive systems in plants—as to preclude any comparison between the great mass of the disorders from which the two kingdoms suffer. But since, in their ultimate structure, they are composed of the same cellular units, and since they are exposed to the attacks of similar parasites, it would be strange if there were no points of contact between vegetable and animal pathologists.

Vegetable pathology is a younger science than that of man and the higher animals, and there are, as yet, no handbooks that give in any detail a comparative survey of the pathological processes in plants.

But, I think, there are grounds for hoping that the older science may yet gain something from the study of certain disease phenomena in plants. The directions in which this may be sought are in certain branches of cellular pathology; in the diseases involving changes in physiological processes, such as altered metabolism; in certain classes of parasitic and virus diseases; and in the effect of environmental conditions on the interaction of host and parasite.

I propose to give only a very few instances of disease processes in plants that have some analogy to those in the animal kingdom, but without attempting to define their exact bearing on particular aspects of human pathology. While they are not specially confined to the tropics they are prevalent there, and my own actual experience has been almost entirely tropical.

The first is tumour formation in plants, as exhibited by the well-known crown gall tumour caused by *Bacterium tumefaciens*. I have recently had an opportunity of going over with Dr. Erwin F. Smith, of Washington, the work on this disease on which he has been engaged for the last eighteen years. It is regarded by plant pathologists, the world over, as one of the masterpieces of scientific work in their field, and has raised Dr. Smith to the position of a recognised leader amongst them.

The tumours produced by this organism on a multitude of plants are usually hyperplasia caused by the repeated division of the cells to produce a solid small-celled tumour tissue without cavities. The cells are often markedly embryonic in character, and divide mitotically and amitotically. Secondary tumours frequently develop, often at a considerable distance and deep-seated in the tissues. They are not caused by migration of the bacteria across normal tissues, but by a definite outgrowth from the primary tumour in the form of a tumour-strand of infected cells of marked characters, and easily recognised in section, though often only a few cells thick. Such strands have been traced for ten inches in length. The secondary tumours have the characters of the primary, so that if a leaf bears tumours from one on the stem, their structure will be a stem structure. Secondary tumours can also be produced by grafting a part of a primary tumour on a suitable part of the plant. Growth of the tumour is unlimited and devoid of polarity, and the destructive action on the plant is usually merely the result of pressure and crushing, though necrosis permitting secondary infection is common.

The structure of the tumour varies according to the tissue primarily infected. Most of them are of the ordinary ground or conjunctive tissue cells, *e.g.*, in the cortex or pith, and are the nearest approach that one could expect to get in plants to Sarcomata. There is no epithelium in plants, and the epidermal tissues are thin, usually a single layer, and hard to inoculate without involving the underlying ground tissue. But a few cases have been described in which the tumour appears to be composed mainly of epidermal elements, including hairs (the plant hair being an outgrowth from a single epidermal cell), and these may be compared with Epitheliomata. The most interesting type, however, is Embryomata. These were first detected as recently as 1916. They are composed of a jumbled mass of young shoots and roots of usually incomplete structure, having only bits of organs, but sometimes forming more or less complete dwarf shoots. The secondary tumours developed from these have usually the same embryonic teratoma structure.

The organism which causes crown gall is a cell parasite of a highly developed type, in which the host cell is not destroyed but is stimulated to increased activity. There are many such cases in plant parasites. To the best of its ability the parasite aims at preserving the life of the host cell for its own needs. That it over-stimulates the cells, causing death by crushing and necrosis, may be regarded, more or less, as an accident.

Bacterium tumefaciens can be isolated and cultivated so that its morphology and characters are well known. It is rare in the tissues, at least in an active state; in one case it was estimated that there were only 200 living bacteria per cubic centimetre of the tumour. But perhaps the most significant thing that I learned from Dr. Smith was that, contrary to his earlier belief, he is not now certain that he has ever recognised the organism in the tissue. What he previously saw he now thinks were only cell inclusions or chondriomes. Thus we have a parasite capable of causing a tumour having all the characters of a malignant growth; the organism has been isolated, grown in pure culture, and new tumours produced at will with it, but it is not with certainty to be recognised in the tissues of the tumour.

More recently Dr. Smith has been able to produce experimentally small tumours of limited growth, having the characters of incipient crown galls, by injecting in suitable parts of plants certain of the diffusible products of the metabolism of *Bacterium tumefaciens*, including ammonia, amines,

organic acids, etc., and he considers that the tumour is ordinarily caused by the continual production of small quantities of these excreted products by the parasite.

I am aware that the path of cancer research is strewn with the wrecks of parasitic theories; but the recent work on plant cancers, the experimental production of embryonic teratomata, the extreme difficulty of detecting the parasite in the cells (it is certainly *in*, not between the cells), and the evidence that it acts by the production of repeated small quantities of an excreted stimulus, makes it easy to understand the view held by Dr. SMITH, and other vegetable pathologists, that cancer will ultimately be found to be due to some similar cause.

A second direction in which disease phenomena in plants may throw light on certain animal diseases is found amongst the obscure group of diseases which the vegetable pathologists are calling "virus" or "contagium" diseases. These are diseases in which etiological studies suggest the presence of parasitic agent, but in which, with the means at our disposal, no parasite can be detected, and filtration through the Berkefeld filter does not cause a reduction in virulence.

The number of such diseases in plants is large, but many of them have only recently been recognised. They have all certain characters in common, but they fall into several groups, the most important of which is that known as the "mosaic" group, because its most obvious symptom is a variegated appearance of light and dark green patches on the leaves. So rapidly have new cases of mosaic been recorded in the last few years that one is tempted to say that every cultivated plant has at least one such disease. Cross-inoculations show that while allied plants (as, for instance, potato and tomato) may suffer from the same mosaic, the mosaics of distantly related plants are usually distinct.

These diseases are constitutional, the virus reaching all parts of the plant in three to four days after inoculation in the mosaic of cucumber. The incubation period before the first symptoms appear in this mosaic varies from four to fifteen days, and in potato and cabbage mosaic from twenty to thirty days. In sugar-cane mosaic the virus is restricted in its distribution, and may not reach every shoot. Many tissues and organs, though containing the virus, do not react to it in any way that has been hitherto detected. Also "carriers" have been found, *i.e.*, plants that show no symptoms after inoculation, yet contain infective virus in a

transmissible form. Actual tissue reactions (cell modifications) are often caused in the leaves and fruit. Necrosis of the light areas in the leaves also occurs not uncommonly in the older stages. The other symptoms are due to deep-seated alterations in the physiological activities of cells and organs, revealing themselves in altered metabolism and abnormalities of growth (dwarfing, crinkling or folding of flat surfaces, shortening of axes, and, at times, proliferation). The disease is not usually fatal in annual plants, though death from weakness may occur. The reduction in vigour may be very great or slight. Mosaic and allied diseases of potato in England may cause a reduction of over 50 per cent. in the yield, and in Bermuda losses up to 75 per cent. have been recorded. On the other hand, I recently saw fields of sugar-cane in Louisiana with 100 per cent. infection from mosaic, but was informed by the local plant pathologist, EDGERTON, that the loss of yield was slight, though the disease has been present for seven years, and in other localities, *e.g.*, Hawaii, has been known to reduce the sugar yield by 60 per cent. The so-called deterioration of many cultivated plants, such as potatoes, leading to the constant demand for new varieties, has recently been recognised to be, in many cases, the result of the gradual accumulation of some one or other of these virus diseases.

From the standpoint of comparative pathology, what is important is the knowledge that has already been gained as to the methods of transmission and certain other characteristics of these virus diseases.

So far as is known all these diseases are insect borne. There are other methods by which infection can be produced, but the normal method in nature is by insects, chiefly sucking insects, especially aphids. In no case has transmission by mere contact been demonstrated. In one case, curly top of beet, no other method of infection than through the insect (a leaf hopper, *Eutettix*) has been discovered, and in this case the insect has to be kept for a period of twenty-four to forty-eight hours after feeding on a diseased plant before it can inoculate a healthy one, after which it can remain infective for 100 days. This suggests that a part of the life-cycle of the parasite is passed in the insect. In most cases, however, the virus can be obtained by extracting the juice (cell sap) of a diseased plant, and can be successfully inoculated on a healthy plant by injection into any part of the plant (tobacco mosaic) or into certain parts only (growing point in sugar-cane mosaic, any part but the root or flower

in cucumber). It can also be transmitted often by crushing a diseased leaf on a healthy one, so as to injure both tissues, or even (cucumber mosaic) by bringing the broken hairs of healthy and diseased leaves into contact. In such cases the virus is evidently in each individual cell. In spinach blight the crushed bodies of aphids that have fed on diseased plants are infective. In this disease, too, the offspring of infected aphids are infective occasionally. In certain cases the disease is carried in the seed borne by diseased plants, but in a good many this does not occur. There is much evidence that the virus travels in the plant through that part of the vascular system, the phloem, in which the elaborated sap is conveyed. This system does not reach to the seed, the plant embryo feeding entirely by osmosis. It is most interesting to note that recent studies show that certain aphids, including some that are known to carry mosaic, feed by inserting their very fine and flexible probosces into the cells of the phloem, avoiding other cells as a rule.

One other method of transmission must be mentioned. Even in the most refractory cases, as beet curly top, infection can be secured by grafting a diseased on to a healthy plant, provided organic union is obtained.

After extraction from the plant, the life of the virus varies from only twenty-four hours (sometimes in cucumber mosaic) to a year or more (tobacco mosaic if dried). It is killed by a temperature usually of between 70°C. and 80°C., but can withstand exposure to very low temperatures. In some cases the ordinary antiseptics kill it, but the tobacco mosaic is resistant to most weak antiseptics. The concentration in the sap is such that a needle drop can be diluted to 1,000 without any loss of virulence, though virulence is reduced by a dilution to 10,000 (tobacco and cucumber). Filtration through porous filters depends on the size of the pore. The cucumber mosaic virus filters through the Berkefeld but not through the Chamberland; tobacco mosaic filters through both, but is retained by powdered talc.

Though there are still a few vegetable pathologists who prefer the enzymic or toxic hypotheses to the parasitic explanation of these diseases, most agree that their study has made it necessary to assume that they are caused by ultramicroscopic living organisms. The mere fact that they have not been successfully grown *in vitro* has no weight with the vegetable pathologist who is familiar with whole groups of parasitic fungi,

such as the rusts, not one of which has ever been grown apart from its host plant. It is as certain as anything can be that no visible organism is present in extracted cell sap that is known to be highly infective. This does not preclude the possibility that the organism may have a visible stage, and indeed quite recently two independent workers have claimed to have discovered, in cells of sugar-cane and maize suffering from mosaic, bodies which in one case may perhaps be suggestive of a parasite not unlike a stage in *Rickettsia*.

Another set of problems, of no less interest to the vegetable than to the animal pathologist, is the geographical and seasonal distribution of certain diseases.

The experimental study of the relations of plants to their environment is naturally much easier than with human beings. In our botanic gardens we habitually grow tropical plants with success, being able to imitate their natural conditions. It is only recently, however, that plant pathologists have made use of their opportunities to study the influences of such climatic factors as humidity and temperature on plant disease. The results have been remarkable. It has been found possible to correlate the geographical distribution of a considerable group of plant diseases with the temperature and humidity reactions of the parasite and its host.

In the simplest cases a single factor, such as the degree of relative humidity of the air, acts by limiting the development of the parasite. One of the best examples of this is a disease of the rice plant which I studied in India. It was strictly confined to a large rice area at the head of the Bay of Bengal, and while the main crop from July to December was often totally destroyed, the secondary crop in the spring entirely escaped, though it was shown by artificial inoculations to be equally susceptible. I found that the organism could neither move nor feed nor reproduce at an air humidity of below 90°, while, though it is actively mobile, it is unable to feed or reproduce in water. To be able to multiply and attack the rice plant it therefore requires moderately prolonged periods when the air humidity is over 90°. This it only gets in certain limited areas in India during the second half of the year; and at a time when the disease was causing considerable alarm, it was possible to state that the bulk of the rice-growing area was not threatened.

The meteorologic factor may act by affecting the receptivity of the host-plant. Thus in the vine mildew, infection is dependent on the

condition of the stomata, through which the parasite enters. If these remain semi-closed, as in young leaves or in dry conditions, infection is impossible. Infection has been found to fail if the moisture of the soil in which the vine is growing is below 15 per cent., unless the air humidity is above 80 per cent. If the soil moisture is above 20 per cent., the stomata open widely enough to permit infection at air humidities above 40 per cent.

But it would seem that in many cases the action of the meteorological factors on both the parasite and the host in their mutual relations—on what may be, for convenience, termed the host-parasite complex—has to be taken into account. In the onion smut, for instance, it is possible to get 100 per cent., or no successful infections, according to the soil and air temperatures used. The onion seed will germinate at soil temperatures from 10°C. to 30°C. but the best top growth is got with the soil temperature of 20°C. to 25°C. Infection by the smut fungus can be got freely from 10°C. to 25°C. but is slight at 27°C. At a soil and air temperature of 25°C. a great many plants will outgrow the infection and recover, but at an air temperature even as high as 30°C. to 33°C., infection can be got if the soil temperature is kept below 25°C. In outdoor plantings the disease was completely inhibited when the mean soil temperature reached 29°C., and increased progressively with lower temperatures. The relation is believed to act chiefly through the host-plant, as successful incipient infection can be got at the higher temperatures, but the subsequent development of the fungus is inhibited. The geographical distribution of the disease in the United States, where it is absent from large areas in which onions are sown in the warm season, has been completely explained by this work.

Recently it has been shown that the severe outbreaks of epidemic malaria in the Punjab are governed by a set of temperature and humidity factors affecting both the malarial parasite and the insect host. With a warm-blooded animal like man the temperature factor is probably of slight importance, except in so far as it acts on the parasite while exposed to the air, as in the external air-passages. But in insect-borne diseases, and in the life of the parasite outside its host, these studies have a certain interest, and the recent discovery that so small a difference as 5 per cent. relative humidity or 3°C. or 4°C. temperature can cause a difference of 100 per cent. in infection has come as a surprise to many plant pathologists.

In these few instances, selected from widely different fields, I have tried to show that the problems which face the vegetable pathologist are often akin to those of human pathology. Where there is any evidence that disease processes are fundamentally alike in plants and animals, I venture to think that they are worth careful examination by pathologists generally. Their study in plants has many obvious advantages in the ease of experimentation and manipulation.

Vegetable pathology is under a great obligation to the older science, from which many of its methods and principles are borrowed, and there could be no more fitting way of repaying this debt than by the discovery that the study of plant diseases may throw light on some of the more obscure problems of human pathology.

Discussion.

Dr. A. Balfour: I think we must all welcome this paper very much. It is rather out of the usual run of papers which are given here, but it is the more interesting and instructive on that very account.

There are two matters to which I would like to make brief reference. The first, which is only indirectly associated with Dr. Butler's paper, is one which I know Sir Patrick Manson has had in his mind for many years, though I think he has never written about it. He is not here, but I do not think he will object to my mentioning the subject. It is the question, Why do certain plants produce alkaloids? Many of these are very poisonous substances; some are distinctly disagreeable to the taste. Sir Patrick asked me whether I thought these alkaloids were developed for the protection of the plants, for instance, against insect attacks. In cinchona bark there are, of course, quinine and other bitter alkaloids, and it would be interesting to know if those particular plants are subject to insect-borne diseases.*

The other point has a definite relation to the subject of the paper, namely, the production of gum by plants—a matter of great importance to those living in the Sudan, where gum acacia is one of the staple products. This production of gum is a diseased condition common to certain species of acacia tree, when they occur in dry regions and do not receive sufficient moisture. When the plants are well supplied with water this

* The interesting question of the function of alkaloids in plants is discussed by Annett in his "Investigations on Indian Opium." No. 2, in the *Memoirs of the Department of Agriculture in India*, Vol. VI., No. 2, Sept., 1921.—A. B.

gum is not produced. In Australia, the work of GREIG SMITH showed that bacterial infection, in the case of two species of acacia, was responsible for the production of gum from the sugars of the sap. Later, RUHLAND isolated from diseased cherry trees an organism, now called *Bacillus spongivans*, which he cultivated, and which he found produced slime and gums.

Certain of the Ambrosia beetles have been incriminated by ZIMMERMAN as a cause of gum production, owing to the injury produced by their boring habits. In the Sudan, EDIE isolated a bi-polar staining organism from two species of acacia, and he cultivated this in a liquid medium containing levulose, glycerine, asparagin and potassium citrate; when so cultivated the organism produced slime and, eventually, gum. These are all very interesting observations, because it was definitely shown that gum is only formed when the tree is damaged, and a point of inoculation provided for the causative organism. EDIE proved that flies were operative, probably by conveying the bacterium in the gum from one tree to another. It is also possible that ants may be effective. I think this gum production may be a protective action on the part of the plant, and may possibly, in some cases, be analogous to the scab which forms over a wound and, to a certain extent, protects the latter from insects, and from invasion by micro-organisms.

Dr. P. H. MANSON-BAHR: We have evidence of *Bacillus tumefaciens* causing tumours in plants, yet the bacilli could not demonstrate in the tissues. This is a well-marked exception to the second of KOCH'S postulates. I think this should give us a lead in our further study of human pathology. In such a disease as sprue it may be possible for an intestinal bacillus to be responsible for the pathological condition, yet that bacillus, though it may be isolated by culture, may not be demonstrable in sections of the gut itself.

Dr. T. P. BEDDOES: I would like to ask to what extent there has been any treatment. When it comes to management of woodlands, certainly an improvement can be made. Take, for instance, one of the most destructive diseases—the larch disease. Instead of growing the larch unprotected in the open, if it is grown among other trees, such as the oak, then it grows in better condition. By management, woodlands can be very much improved in the matter of protection from diseases.

Another question of interest is as to how far lime and manure affect treatment. There is nothing more interesting than to consider the use of lime. It was first introduced by the Romans, and, for many years, England was the centre of the lime trade, the substance being exported to Holland and the Lowlands. Then the industry went out for many years, and at about the middle of the eighteenth century in it came again, and certainly with very great improvement. Thus I am prompted to ask to what extent management—*i.e.*, the promotion of nourishment and similar factors—lessens the injurious conditions which are being discussed.

Dr. J. C. G. Ledingham commented, as a welcome sign of the times, on the increasing evidence of helpful co-operation in problems of common interest between pathologists and bacteriologists in all spheres of microbiology.

The following also took part in the discussion:—Dr. C. F. Harford, Mr. A. D. Cotton, Mr. A. L. Sheather, Sir Percy Bassett-Smith, and Dr. C. M. Wenyon.

The President: We sincerely thank you, Dr. Butler, for having taken us over this new ground. I think plant pathology will find a place in the ordinary medical curriculum in the Tropical School, though this new subject may be thought by some to be making confusion worse confounded.

We are very much indebted to Dr. Butler and the various gentlemen who have spoken and brought up points of interest; and if each contributes his particular knowledge to the discussion going forward, we shall all learn a great deal.

Dr. E. J. Butler: Recently some work has been done in France on the group of so-called alkaloid producing plants, so as to study such substances as nicotine and atropine. In some cases, such as the aconite, it was shown they were definitely resistant to parasites if in concentration. Nicotine was not of sufficiently high concentration in the plant to have an effect on the organism. Certainly, many plants do successfully resist infection, because they have alkaloid in them, though whether the action is definitely protective is more doubtful.

GREIG SMITH has shown gum production to be due to bacteria in a certain group of cases, but, in the commonest kind in this country, a parasite has not been detected; it is apparently a gummy degeneration of the cell wall, and the conditions which bring it out are a rapid alteration in the degree of humidity of the surrounding air. There is a sugar form to which Dr. GREIG SMITH has drawn attention. So far as I know these gums are not protective, and I am speaking of the acacias.

So far as I am aware, no work has been done in the way of conferring protection. In a few cases it has been said that products have conferred immunity to plants, but on careful examination every supposed instance has broken down.

I believe the transmission experiments to which I have referred have been done only on plants of the same species. I think Dr. SMITH has worked that out, but I cannot say definitely.

Replying to Dr. MANSON-BAHR, in artificial inoculation there is no difficulty in recovering the organism from the plant, though it cannot be seen there. Dr. SMITH has repeatedly cultivated the organism after the disease has been produced, though he could not see it while it was in the tissues.

In answer to Dr. BEDDOES, much work has been done on the control of these diseases, but it would take too long now to speak of it in any detail. The tree disease has been shown to be associated with attacks of certain large insects, and if you can keep the wounds down which are so produced, you improve the trees very much. Larch disease is said to occur more on certain soils than on others, and that is so with other groups of plants. There are plants which suffer from having excessive lime, and others which suffer from an insufficiency.

A paper was read by Dr. W. SALISBURY SHARPE, M.R.C.P., F.R.C.S., on "Diseases of the Ear in Relation to Life in the Tropics." This has been published in the *Journal of Tropical Medicine and Hygiene*, February 15th, 1922.

COMMUNICATIONS.*

INFECTIOUS ABORTION OF CATTLE AND ITS POSSIBLE RELATION TO HUMAN HEALTH.

BY

L. E. W. BEVAN, M.R.C.V.S., *Government Veterinary Bacteriologist, Southern Rhodesia.*

[Delivered before the Southern Rhodesia Veterinary Association, Salisbury, 12th November, 1921.]

This meeting of the Southern Rhodesia Veterinary Association has been convened in order that its members may again discuss the very serious disease of cattle known as infectious, contagious or epizootic abortion, which since our last meeting has assumed alarming proportions in this country ; and in view of the recent suggestion that the disease may be infective to man, the members of the medical profession have been invited to assist in our deliberations.

The close association and interdependence of our two professions are daily becoming more noticeable, especially in tropical and sub-tropical countries where the diseases of man and animals are so closely allied. Undoubtedly the best and most scientific manner of studying such diseases is from the comparative standpoint, and the subject of my paper to-night affords an example of the necessity for co-operation between us.

For my part I have to bring before you certain aspects of the disease as it occurs amongst animals in this territory, but in the course of my remarks I may throw out hints which it is hoped may prompt the members of our sister profession to enter into the debate, and to bring forward any information they possess having a bearing upon the disease as it affects the human population of this colony.

There is no doubt that the future prosperity of Rhodesia principally depends upon the progress of the pastoral industry, but it is sad to relate that since the advent of the white man, the herds of this country have

*With a view to making the TRANSACTIONS more interesting, it is proposed to insert SHORT COMMUNICATIONS from Fellows relative to any matters of medical, sanitary or parasitological interest. It is felt that many Fellows in various parts of the world must be in a position to contribute short papers on these subjects, and the Secretaries will be pleased to receive any such from them.

twice been decimated by bovine scourges. On the arrival of the pioneers it is said that the country was "rolling with cattle," but in 1896 the greater number of them were destroyed by rinderpest, which passed through this country on its way to the south. Notwithstanding this disaster the survivors, in the words of the Bible, brought forth their thousands and tens of thousands, until the industry was again upon a sound footing, only to be again destroyed by East Coast fever, which arrived in 1901, and has only recently yielded to the scientific efforts of the Veterinary Department.

At the present time it is officially stated that there are about one and a half million head of cattle in the country, owned equally by black and white, but, alas, the industry is again threatened with a new disaster in the appearance of this insidious and costly malady known as infectious abortion, a disease which is now known to exist in all parts of the territory.

The first outbreak recorded in this country was in a dairy herd in Salisbury, in 1906. This was promptly and vigorously dealt with, and was apparently stamped out. Although abortions undoubtedly continued to occur, they were not reported to the Veterinary Department, and it was impossible to determine whether infectious abortion as a specific disease was the cause of them until 1914, when the agglutination test was first applied as an aid to diagnosis. Since then it has been found to exist from Umtali in the east, through Rusapi, Marandellas, the Beatrice District, Enkeldoorn, Umvuna, Gwelo, Shangani, Bulawayo, and north to the Lomagundi District. In fact it is probable that it exists in cattle belonging to Europeans and natives alike throughout the country. It is equally prevalent in Northern Rhodesia, and, as far as one can gather, throughout the Union of South Africa.

This disease is not confined to Africa. In Great Britain it is second only in importance to and probably more prevalent than tuberculosis. In America it is stated by the Bureau of Animal Industry to be the cause of the loss of many millions of dollars yearly through its presence in dairy and range cattle. In New Zealand the losses in dairy products directly and indirectly attributable to it are estimated at £300,000 per annum.

In many ways this disease affects the human population of this country. The last census revealed a somewhat lamentable state of affairs

and a population of little more than 33,000 white people. A great proportion of these are dependent upon the cattle industry, and I doubt very much whether, after his sad experience in the past, the Rhodesian settler, however stalwart he may be, can "stand up" to another disaster. And if it is found that this disease of cattle is infective to human beings, the situation is fraught with grave dangers, and we, the guardians of the public health, are faced with a grave responsibility if we wish to see Rhodesia, our adopted country of which we are so proud, survive the storm.

It has long been known that abortions, even in such numbers as to suggest some common cause, were apt to occur among domestic animals, and various reasons were advanced to account for them, as, for example, feeding upon ergotised pasture, sewage poisoning, mechanical injury, over-exertion, fright or sympathy; but as long ago as the beginning of the last century keen observers maintained that "an infection was the causative agent." The correctness of this view was proved later in the century, when abortion was artificially produced by the introduction of vaginal discharge and fœtal membranes into the vaginas of healthy cows. It was not, however, until 1896 that BANG and STRIBOLT demonstrated the specific cause to be the bacterium known as the *Bacillus abortus* of BANG, and, having cultivated this organism, in bringing about abortion by the injection of pure cultures into the vagina of pregnant cows and ewes. Also injections of cultures into the circulation produced similar results. Later, MCFADYEAN and STOCKMAN demonstrated what is of still greater practical importance, that pregnant animals could be infected by feeding upon infective material, either artificial cultures or natural exudates from infected animals. In these cases artifically produced, the characteristic lesions of the disease were met with, and the bacillus could be recovered from the exudate of the fœtal membranes, the diseased cotyledons, and the intestinal contents of the aborted fœtus.

It is probable that the organism had been noted by previous observers, but it remained with BANG to isolate the bacillus, which required for primary cultures not only a specific medium, consisting of nutrient agar to which liquid gelatin and sterile liquid blood serum had been added, but also an optimum growth temperature of 37° C., and a special oxygen content indicated by the fact that the colonies develop in a definite stratum of a few millimetres below the service. The

B. abortus is thus not a strict anaerobe, but has been classified as a micro-aerophile.

Various devices have been made use of in order to establish a primary culture and to afford the special oxygen requirements. But it would appear that in subcultures the organism can accommodate itself to ordinary aerobic conditions. Under such conditions surface colonies develop in about three days as small, usually discrete honey-like dots. These later tend to coalesce and to form a creamy film, which in time becomes darker in colour, and in very old cultures is actually coffee-coloured or brown.

The medium upon which the strain used in our laboratory, and to which the organism appears to have become well accommodated, is prepared as follows:—

Lemco	5 gm.
Sodium chloride	5 gm.
Peptons	10 gm.
Agar	27½ gm.
Water	1 litre.
Glycerine	3 per cent.

added to the filtered medium which has previously been rendered alkaline.

Surface growths upon this medium are well established in three days, and fully developed growths suitable for vaccines are available within a week. A certain degree of moisture favours the growth, and for vaccines it has been found necessary to conserve in a special manner the water of condensation. Too much moisture, however, alters the cultural characteristics of the growth and the properties of the organism.

The *B. abortus*, both in natural and artificial conditions, tends to collect in clusters, and these are to be met with in the affected chorion, cotyledons, characterised exudate and discharges, and in the stomach of the fœtus. They are stained readily by basic aniline dyes, but in the clusters the morphology is difficult to define. The term coccobacillus has been used to describe the organism, from the fact that coccoid and elongated coccoid or bacillary types are met with.

Some difficulty is experienced in establishing primary cultures, chiefly on account of the peculiar oxygen requirements of the organism. Several ingenious methods have been devised to cope with this, for example,

suspected material is sown on a medium, which is placed in a closed jar with other tubes containing common aerobic organisms, which exhaust the oxygen until the stage when the *B. abortus* finds the atmosphere congenial. This method is made use of to separate the *B. abortus* from other organisms with which it may be associated in septic discharges; but, perhaps, the best method of obtaining a pure culture is to inoculate suspected material into guinea-pigs, when the *B. abortus* becomes established in the spleen, which becomes enlarged, and sometimes, after two or three months, beset with tubercles. In a few weeks, however, the organism is present in the spleen in pure culture, and in such numbers that, when small pieces of spleen substance are spread upon agar slants, a characteristic growth can be obtained. This method has proved useful in demonstrating the presence of the specific micro-organism in the udders and milk of apparently healthy cows acting as carriers of infection.

In 1918, EVANS pointed out a close relationship between the organism responsible for infectious abortion of domesticated animals and the so-called *Micrococcus melitensis*, the cause of the well-known undulant or Malta fever in man. More recently MEYER and SHAW have stated (*Jl. Infect. Dis.*, 1920, Sept., Vol. 27. No. 3, pp. 170-184) that "on morphological grounds the organisms of undulant fever and infectious abortion of domesticated animals must, therefore, be considered as identical," and suggest that a genus, for which they propose the name "Brucella," be created in the family Bacteriaceæ, to separate and distinguish properly these important micro-organisms.

The serum of animals affected with infectious abortion will agglutinate the *B. abortus*, and, in 1914, BEVAN was able to demonstrate that the serum of cattle suffering from the disease in Southern Rhodesia would agglutinate strains of *B. abortus* obtained from Great Britain, the Union of South Africa, and British East Africa. Similarly, serum from natural cases of infection in British cattle would cause agglutination in emulsions of these strains. This observation suggests that the causal organism of bovine abortion in Southern Rhodesia is similar or identical to the *B. abortus* causing the disease in other parts of the world—a matter of some importance, as will be seen later. It is probable, however, that there are different strains of the organism of varying virulence, just as there are strains of the *M. melitensis*; and it is conceivable that there may be a certain overlapping of strains of the two organisms.

In February last, a patient from the Shamva District was admitted to the Salisbury Hospital, and his serum was obtained by Dr. Peall and tested by Bevan against cultures of *B. abortus*, with which it caused rapid and marked agglutination in dilutions of 1 in 200. This, I believe, was the first demonstration of a co-relation between the abortion of cattle and undulant fever of man in this country. The test was prompted by an article by Feusier and Meyer, in which they showed by serological tests a close association between *B. abortus* and *M. melitensis*, and pointed out that certain strains of *M. melitensis* bore a closer relationship to the abortion bacillus than to other strains of melitensis. They also demonstrated that "the serums from cows and hogs suffering from natural abortion disease may also react to both *B. abortus* and *B. melitensis* organisms."

Recent observations by Orpen, working in the laboratory of the Medical Department, and by Bevan, working independently, reveal a very serious state of affairs in this country, if serological tests and cross-agglutination reactions are to be regarded as indicating any corresponding pathogenicity of the organisms.

The possibility of such an association has engaged the attention of numerous observers for many years past in other parts of the world, and in July, 1916, Cooledge, in the *Journal of Medical Research*, reviewed the experiments made up to that time by several observers. Mohler and Traum obtained cultures from guinea-pigs inoculated from the tonsils and adenoids of fifty-six human beings, and obtained from one case distinct lesions of infection in the liver, spleen and testicles, from which the *B. abortus* was recovered.

Larsen and Sedgwick made an extensive study of human infection by this organism. They examined the blood of 425 children, and obtained 73 positive reactions by the complement-fixation method. They also found that an infant taken from the breast on the seventh day after birth and fed on cow's milk, gave a positive reaction on the twenty-first day. Cooledge himself examined the blood sera of 14 persons drinking raw milk, pasteurised milk, and no milk, and found that of the persons who had been taking raw milk or cream previous to the test, three (or 50 per cent.) gave a reaction to the complement-fixation and agglutination tests. One woman, whose blood reacted to the test, had been drinking milk which was found to contain *B. abortus* antibodies, and had been drawn

from one quarter of a certain cow. One man, whose serum gave a partial agglutination at 1 in 100, had been drinking about a pint of raw cream daily during the summer. These results satisfied the author that the presence of antibodies in human sera is due to the ingestion of infected milk, and may indicate either active infection or merely a passive immunity due to the absorption of antibodies from the milk, and he adds "we have no proof that *B. abortus*, BANG, is pathogenic for human beings." No reference is made in these reports to any symptoms in these reactions suggesting undulant fever; nor are we told whether abortion at any time took place among human females fed upon infected milk.

It should be remembered that in natural conditions abortion due to this organism is essentially a disease of cattle, and it is stated by the Departmental Committee appointed in 1905 by the Board of Agriculture and Fisheries to enquire into epizootic abortion, that it had no hesitation in stating that it believed at least 99 per cent. of the outbreaks of cattle abortion which assumed epizootic characters, to be due to infection by the bacillus of cattle abortion.

Mares, sheep and swine may also become infected with the bacillus of BANG under natural conditions and by artificial methods. Goats, guinea-pigs and rabbits have also proved susceptible, and it may well be that the human female is not exempt.

Natural infection occurs by the vagina or by the mouth. It is probable that ingestion is the most common method. The bull is occasionally a mechanical transmitter of contagion, and it has been shown that the organism may become localised in the vesiculæ seminales, deferentia, testes and epididymides of the male, which may thus become a carrier of infection.

The symptoms in cattle may be briefly described. The disease is generally most severe in heifers and young cows, but may attack a susceptible animal of any age and at any stage of gestation. It is said that "the majority of cases of 'visible' abortion occur between the fifth and seventh month of gestation; the average period is between the fifth and sixth month, if a reliable estimate of the early or invisible abortions could be made. Some cows abort about the first or second month, and no suspicion is aroused until œstrum recurs a few days later" (AINSWORTH WILSON). The suspicion that animals may frequently abort unnoted is confirmed by our observations in the country.

The course of the disease is insidious, and its existence is often unsuspected until the shortage of calves draws attention to its presence. In this country the diagnosis is confirmed by a special modification of the agglutination test.

The act of abortion is generally easy. Premonitory symptoms may or may not be present, and in many cases the fact that abortion has taken place is only detected by the discovery of the fœtus or by a peculiar yellow flocculent discharge which soils the tail and hind parts, or by the retention of the after-birth, which is a very frequent sequel. Particular attention may be drawn to the fact that there is no appreciable effect upon the animal's general health and condition; that is to say, febrile disturbance, anæmia, rheumatic pain or indications of neuritis have not been observed. Pathological changes are almost entirely confined to the uterus and to its contents. The mucous membrane may be in a state of catarrh and a typical exudate may cover the chorin. This is somewhat characteristic, being of a lightish yellow colour varying to dark brown. The membranes may be œdematous and the cotyledons may be swollen, and occasionally necrotic. The fœtus frequently appears quite normal; it is sometimes mummified, but is rarely putrid.

The disease may be regarded as a disease of the fœtal membranes. If the animal is not pregnant the organism can produce no pathogenic effects, and it is known that in apparently healthy animals the udder may be heavily charged with abortion bacilli, without harm to the animal until it becomes pregnant, when the organism may again make its way to the uterus. Schroeder and Cotton record "a number of calves produced by cows with infected udders were killed immediately after they were born, and their bodies tested for the presence of abortion bacilli through guinea-pig inoculation methods. It was found that such calves —those that were delivered alive and seemingly healthy and vigorous— may harbour bacilli in their stomachs and gastrohepatic lymph glands, but invariably, when the calves were infected, the after-birth and uteri of the dams were also infected." Animals that thus harbour the organisms in their udders are a constant source of danger—certainly to cattle, possibly to man. They act as carriers, and may be the means of infection of a perfectly clean herd, or of re-infection in a herd which in the course of time has become clean. So long as such animals are in lactation the bacilli may be excreted in the milk. If the human subject is liable to a

disease caused by this organism, this source of infection is of considerable importance.

Let us now compare the symptoms of Malta fever in goats. The following description by DUBOIS is quoted by EDWARDS, in a most comprehensive paper read by him before the National Veterinary Medical Association, to which I am largely indebted for many of the details I have brought before you. DUBOIS writes, " . . . in the goat there are as a rule no visible symptoms, and the animals maintain to all appearance their good health, the onset of the disease always passing unnoticed . . . . The most important symptom, and the one that would always make one suspect Malta fever, is abortion, but even that is not constant, nor is it diagnostic. When the disease makes its appearance in a herd for the first time, the percentage of abortions may be anything from 50 to 90 per cent. of the pregnant goats. If these goats are again served, abortion occurs again, but the percentage is not so great as on the first occasion. Abortion may cease completely in a herd, but this does not make the danger any less, as a certain number of animals always harbour the parasite. Sterility is rarely observed." " In the sheep the symptoms shown closely resemble those in the goat, and, as in the goat, abortion is the most important symptom." " In all animals, independently of the clinical symptoms, the blood serum, urine, and milk possess agglutinating powers for *M. melitensis*. The value of the (agglutination) test (in diagnosis) is indisputable, but since the serum may retain its agglutinating power for years after all trace of infection has disappeared, a positive result only indicates that the animal is or has at one time been affected."

Thus we see that *M. melitensis* causes in certain of the lower animals a disease similar to that caused by *B. abortus* in cattle. But it also gives rise to a disease in man characterised by entirely different symptoms. In Rhodesia a number of cases have recently occurred among human beings who have shown the clinical manifestations of Malta fever, but, as far as can be ascertained, have not imbibed goat's milk, but have resided on farms where infectious abortion of cattle is known to exist. Circumstantial evidence, therefore, points to infection through infected cattle, but direct proof is not yet available.

The most powerful argument against the infection of man by the *B. abortus* of cattle is advanced by EDWARDS in the paper referred to.

He says, " . . . there can be but little doubt that the two organisms (*i.e.*, *M. melitensis* and *B. abortus*) differ in the all-important property of pathogenicity, for otherwise, in view of what we know concerning the excretion of the abortion bacillus in the milk, and the large percentage of cows that act as carriers of the bacillus, a large part of the population of Northern Europe and the United States would be liable to infection, but evidence to hand has failed to prove that the drinking of milk from aborted cows is a source of danger to human beings." On the other hand, it has been stated that Malta fever does not originate north of latitude 46°, but cases have been observed in England by MANSON himself. It has been pointed out that Switzerland and South Germany are the home of the milch goat. Nevertheless, these countries are particularly free from Malta fever.

If *B. abortus*, even occasionally, caused in man, in other parts of the world where infection of cattle is common, the remarkable symptoms manifested by patients from the Marandellas District and elsewhere in this country, the fact must surely have been noted ; or if the symptoms of Malta fever were common in countries where the drinking of goat's milk could be excluded as a possible source of infection, but where infectious abortion was known to prevail, the circumstance would scarcely have been overlooked. It is certainly remarkable that although specific abortion of cattle has been prevalent in the Marandellas District since 1914, it is only within the last few months that the so-called Malta fever cases in man have been detected.

The suspicion that abortion among human females might have been associated with the drinking of infected milk, however, has frequently been suspected and suggested.

It is also a fact worthy of consideration that on farms where men have been infected, the other members of the family have apparently escaped, although if infected milk is the cause of the disease, one would have expected the women and children to have been the chief victims.

In this connection it should be mentioned that the Malta fever organism is not a delicate organism, and is very resistant to desiccation. It is, therefore, probably blown about in dust. Moreover, it is excreted in the urine of apparently healthy goats and cows. Possibly the *B. abortus* is disseminated in a similar manner, and, if so, suspicion might fall upon the dust of cattle kraals where infected animals have been herded, which

would explain the large proportion of cases among males as compared with women and children.

Another statement made by EDWARDS may be quoted. He says: "Experimentally it has been found quite easy to infect and cause abortion among other farm animals and in small laboratory animals by causing them to be inoculated with, or to ingest, doses of BANG'S bacillus, and it is quite possible that even man may become infected; but the natural reservoir of the disease-producing organism is the cow, and there is every reason to believe that just as the bovine type of tubercle bacillus would cease to exist if bovine tuberculosis were completely eradicated, so would BANG'S bacillus no longer persist if the bovine species became extinct. In devising control measures, therefore, other animals than cows need not engage our attention."

A grave responsibility is thus imposed upon my profession, and I may be forgiven if I give a brief outline of the measures which have been adopted by the Veterinary Department of this country, in its endeavour to cope with a disease which, up to the present, has defied the efforts of administrations in other parts of the world.

At a meeting of the professional officers of the Veterinary Department, held in the Veterinary Department, Salisbury, in August, 1920, to discuss this disease, it was decided that:—

> "Official quarantine of infected farms and herds was impracticable, and tended to defeat its own ends by leading to the suppression of information as to the existence of the disease. Similarly, the publication of notices on the doors of magistrates' courts and in the Government *Gazette* was not desirable. It was admitted that the only method at present available to the Veterinary Department of limiting the distribution and dissemination of the disease was in the power of veterinary officers to refuse permits for the removal of infected or suspected cattle.
>
> "It was decided that the best method of controlling the disease from the point of view of veterinary administration, at the present time, was to educate and assist the public, and it was suggested that veterinary officers should, when possible, deliver lectures on the subject in their respective districts.
>
> "It was agreed that the best method of detecting or determining the specific nature of any outbreak of abortion was by BEVAN'S

modification of the pipette method of collecting blood for the agglutination test.

"The advisability of advising purchasers of cattle to buy 'subject to the test' was discussed, but it was not considered feasible. It was decided, however, that veterinary officers should warn and give advice to buyers contemplating purchase of animals likely to be infected.

"It was agreed that the reports received from veterinary officers and stock-owners as to the efficacy of the vaccine as prepared at the Veterinary Laboratory by the Bacteriologist were most satisfactory, and it was decided that the method should be recommended and applied when possible, that is, when supplies were available.

"The danger of the bull as a source of infection was discussed, and it was decided that all bulls in infected herds should be tested, and, if yielding a positive reaction to the agglutination test, should be destroyed, the test to be applied before vaccination. It was decided that non-reacting bulls should be removed from the herd for a period of six months, and should be vaccinated with the devitalised vaccine.

"It was decided that all female stock in an infected herd should be vaccinated with devitalised vaccine, including calves, and in this way an immune herd should be established. New stock should not be introduced to the herd until a normal calf crop indicated the immunity of the herd, and then only after inoculation.

"It was agreed that so-called 'queen' cows were a source of danger and should be tested, and, if reacting, should be destroyed.

"It was decided that vaccine should be issued through the district veterinary surgeons, in order that they might be aware of the existence of the disease in their districts, the first vaccination to be under the control of the veterinary officer in charge, but, if necessary, subsequent injections to be performed by the owner.

"It was thought necessary to point out to owners that the vaccination could not restore life to a dead fœtus, but might hasten the immunity of an animal which had aborted and prevent non-pregnant animals from becoming infected.

"It was pointed out that a considerable number of barren cows failed to react, and that these could only be destroyed at the owner's discretion. The cause of their condition was probably other than infection by the *B. abortus*.

"It was decided that in all outbreaks an attempt should be made to trace the source and origin of the infection. It was considered desirable to apply the test when a number of cases of retention of after-birth was reported in a herd."

The special method of collecting blood for the agglutination test referred to is merely a modification of the WRIGHT capsule, used with a certain preservative mixture which is added to the blood to prevent decomposition. Hitherto, in this country and at the present time elsewhere, the technique of collection was crude and unsatisfactory. The animal was secured and generally thrown: a cord was passed round the base of the neck in order to "raise" the jugular vein, from which blood was drawn off into a sterile bottle. The operation had to be conducted under aseptic conditions, any extraneous organism making its way into the blood setting up changes which interfered with the accuracy of the test. The difficulties of successfully maintaining such conditions in veterinary practice may be readily understood by those having any field experience. The result was that at least 95 per cent. of specimens sent for test arrived in a putrid or hæmolysed state and quite unsuitable for diagnosis. The pipette originally devised was merely a piece of glass tubing with a 4 mm. bore, and drawn out to a point at each end. The animal having been secured and its ear damped and dried, a bold cut was made across the posterior auricular vein, so that the blood escaped freely. A small quantity of preservative having first been run into the pipette to about a quarter of its length, the point was applied to the blood accumulating at the wound, so that it was drawn into it by capillarity. The pipette was then sealed by sealing-wax or other adhesive material. By this method at least 95 per cent. of specimens submitted have arrived suitable for testing at the laboratory, and it may be claimed that this simple invention has been the means of detecting the disease in many localities where otherwise it might have been overlooked.

After many experiments a still more simple method has been devised, by means of which the veterinary officer, or indeed the farmer himself, will be able to test suspected animals without sending the material to the laboratory. The method may prove useful to medical practitioners, enabling them to carry out their own tests with *M. melitensis*, or indeed any micro-organism which will react to agglutinins.

Reference is also made to the devitalised vaccine prepared at this laboratory. The term "devitalised" has been coined to distinguish the vaccine from that which is generally referred to as "dead" vaccine, in which the micro-organisms have been killed by heat.

Since 1914 STOCKMAN has applied a vaccine to virgin and barren cows, consisting of enormous doses of living bacilli. This apparently strange procedure is based upon a well-known belief in other countries, that the majority of cows infected with infectious abortion do not abort at the successive pregnancies, or that if a cow aborts a second time, it rarely aborts a third.

It is also a well-known peculiarity in connection with infectious abortion in other countries that, provided infected animals are not introduced from without, the disease tends to wear itself out, and in a few years to disappear from the herd. Also it is known that if a long interval, say four to six months, elapses between abortion and the next impregnation, the cow will carry her calf to full term. These observations suggested that in nature an immunity is sooner or later set up in a non-pregnant female at one time infected, and it was sought by means of the introduction of vaccines containing the living organism to imitate or hasten the natural process. The method, however, is fraught with danger, especially in this country, where it is often difficult to determine whether the cattle are in calf or not, and where primitive methods of transport render it unsafe to issue infective material.

A second method was tested, namely, the inoculation of cattle with vaccines made up of organisms destroyed by heat. STOCKMAN having drawn the deduction that the results did not justify the trouble involved, condemned the method; an example which has been followed by others, in spite of the fact that the conditions under which his tests were made were not free from objections. For example, the dead vaccine was inoculated into cows already pregnant, these cows being chosen from a badly infected herd, so that the fœtus of some of them may have been seriously damaged before the vaccine was applied. German experimenters (ZWICK, ZELLER, KRAGE and GRUNDER) have also found that living vaccine yields the best results, but even with dead vaccines figures show a well-marked reduction in cases. There is, however, in my profession, as in others, a tendency to accept without criticism the voice of the oracles. One grave disadvantage attaches to the living vaccine, namely, that even

when applied to non-pregnant animals the organism may become localised in the udder, from whence, when the animal becomes pregnant, it may infect the fœtal membranes. These being discharged when the calf is born, may set up infection in a clean herd, or re-infection in a herd from which the disease has died out.

BEVAN has shown that the agglutination reaction produced by a heated "dead" vaccine, although not as strong as that produced by living vaccine, is nevertheless quite appreciable; and if agglutination may be taken as an index of the progress of immunity, the reaction set up should prove a valuable adjunct in dealing with this disease. But the heating of an organism to the temperature generally applied in producing a vaccine, coagulates the albumen of the organism and destroys its toxins. It also, as may be seen in the test tubes exhibited, renders the organism insusceptible to agglutinating sera, facts which may be seriously considered by the medical profession, who have to rely so often upon dead vaccines.

To overcome these objections, BEVAN devised a method of destroying the organisms employed in his vaccines by exposure to chloroform, which, although rendering the organism inert, does not destroy its toxins. A vaccine made in this way will still agglutinate, which cannot be said of many of the vaccines composed of organisms destroyed by heat.

Good results have followed the use of this vaccine when suitably applied, as shown by the reports received from district veterinary surgeons, but, in some instances, too much has been expected of it. In most cases where it has been pronounced a failure, careful investigation has shown that instructions were not carried out, or that many of the animals at the time of treatment were already well advanced in pregnancy, and probably infected, so that the expulsion of the calf was inevitable. In some cases also the dose was too small to render the animal immune throughout the nine months of pregnancy, and in future the quantity of organisms to the dose will be greatly increased, and the timing of the injections will have to be altered, so that the immunity conveyed will be maintained throughout the full period of pregnancy. Apart from its intrinsic value, the vaccine is a useful adjunct to administrative measures. The knowledge that animals can be treated has prompted owners of infected herds to report, and has justified the Veterinary Department in refusing permits for the movement of such herds during the three months' period of treatment.

I think we may justly claim that the methods adopted by the Veterinary Department of this country in dealing with infectious abortion are far superior to any obtaining elsewhere. However imperfect they may be, an earnest endeavour has been made to cope with a disease which other administrations have admitted their inability to control, and have removed from the list of scheduled diseases a lamentable confession of inertia and impotence.

CONCLUSIONS.

1. The disease known as infectious abortion of cattle, which exists in Southern Rhodesia, is caused by the *B. abortus* of BANG, and serological tests indicate that it is identical with the specific abortion of cattle in other parts of the world.

2. The *B. abortus* of BANG bears a close morphological and biological resemblance to the *M. melitensis*. Serological tests also indicate a close affinity, in that certain strains of *M. melitensis* can be agglutinated with serum from cattle infected with infectious abortion, and strains of *B. abortus* can be agglutinated by serum from human patients suffering from undulant fever.

3. The characteristic symptom of undulant fever in goats and sheep is abortion.

4. Certain cases presenting symptoms resembling undulant fever have occurred in Southern Rhodesia in men who, as far as is known, have not obtained infection from goats, but have resided on farms where animals are or have been infected with infectious abortion.

5. It is suggested that these cases are suffering from an infection caused by the *B. abortus* of cattle.

6. It is also suggested that human females may contract infectious abortion through the ingestion of the organism in milk and dairy products from infected cows.

7. Although infectious abortion is prevalent in other parts of the world where goat's milk is not used for human consumption, it has not been accused of causing the symptoms of undulant fever in man, nor has it been proved to cause abortion in human subjects.

8. Although infectious abortion has prevailed in the Marandellas District for many years, it is only within the last few months that cases resembling undulant fever in man have been recorded.

9. While circumstantial evidence points to the infection of man by the *B. abortus* of BANG, and scientific tests up to a point support this suspicion, the final proof is not yet available.

10. If infectious abortion of cattle is essentially a bovine disease, a grave responsibility attaches to the Veterinary Department; and if this disease is communicable to man, a hearty co-operation between the medical and veterinary professions is necessary in dealing with it.

A SIMPLE CONTAINER FOR TRANSPORT OF SMALLPOX LYMPH IN THE TROPICS.

By H. LYNDHURST DUKE, B.A., B.C., M.D., *Bacteriologist, Entebbe, Uganda Protectorate.*

The following is a brief account of a simple carrier for smallpox lymph in the tropics. The container has been designed by Mr. E. C. Haddon, Laboratory Assistant, Uganda. It is of strong construction, and can be made quite cheaply in the bazaar.

Certain experiments have been performed to test the efficacy of the container, as a means of maintaining lymph at a lower temperature than that of the external air. Mr. Haddon's results, which were obtained with a crude model, show that, with water as the sole cooling agent, a marked difference is maintained between the temperature in and outside the apparatus, even under very adverse conditions of maintenance. This container will receive a further trial in Uganda, and it is hoped that this note will induce others to give a trial to this simple, strong, shock-absorbing and easily-made apparatus.

The experiments carried out are as follows:—

Test No. 1—20th October, 1921.

Conditions of Test.—The glass phial, marked *A* in the diagram, represents the receptacle in which the lymph, made at the Entebbe Laboratory, is at present transported. Under the present system of transport the phial is then dropped into a close-fitting, hollowed-out wooden block, padded at either end with a plug of wool, and the block enclosed in brown paper.

In Test No. 1, two similar phials are taken, and 40 c.c. of tap-water are placed in each in lieu of the actual lymph. One phial, *A*, is placed in the apparatus, in the position shown on diagram; the other—the control *C*—is dropped into its wooden block. Both apparatus and control are then placed on the ground, on a white pad of wool, in full glare of

the sun. A thermometer was placed on the pad alongside. The advantage of the apparatus over the block is shown by the following readings :—

Time	External Temp. °C.	Temp. of A. °C.	Temp. of C. °C.	Ext. T.—Temp. of A. °C.
9.15 a.m.	31	22	22	9
10.0 a.m.	32	22·5	25·5	9·5
10.40 a.m.	31	24·5	30·5	6·5
11.30 a.m.	40	25	33	15
12.0 noon	37	25·5	35	11·5
1.30 p.m.	35	24	35	11
2.30 p.m.	33	25	35	8
3.30 p.m.	31	24·5	32·5	6·5
Apparatus removed to laboratory room and placed on the bench.				
4.0 p.m.	27	23	29	4
5.0 p.m.	24	20	24	4

Test No. 2—21st October, 1921.

Conditions of Test.—The apparatus had been left on the laboratory bench overnight, and the tests or observations were continued in the laboratory on the following day. The external temperature was obtained by laying the thermometer on the laboratory bench :—

Time.	External Temp. °C.	Temp. of A. °C.	Temp. of C. °C.	Ext. T.—Temp. of A. °C.
8.30 a.m.	24	20	24	4
10.0 a.m.	25	21·5	24·5	3·5
12.0 noon	26·5	22	25·5	4·5
1.30 p.m.	27	22·5	26·5	4·5
3.30 p.m.	27·5	23	27	4·5

Test No. 3—22nd October, 1921.

Conditions of Test.—Apparatus placed in incubator which contained a large open vessel of water :—

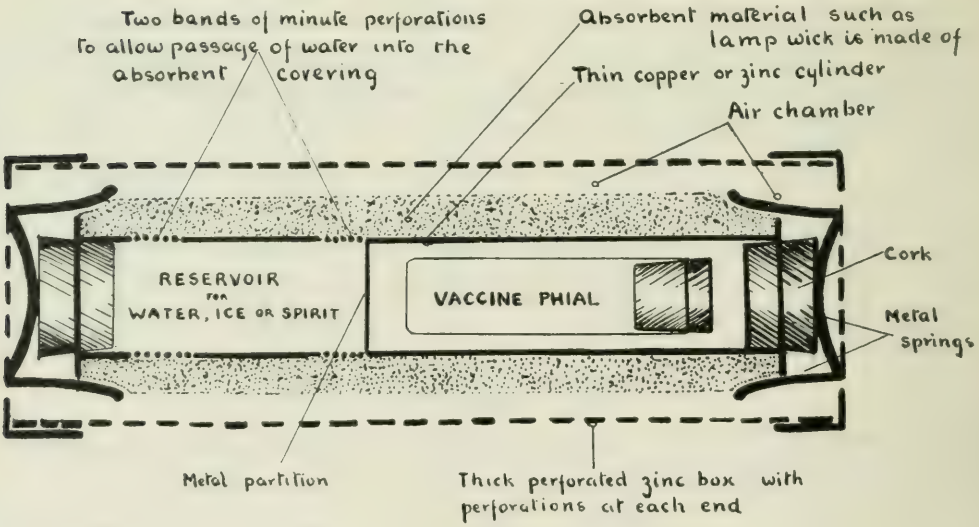
Time.	External Temp. °C.	Temp. of A. °C.	Temp. of C. °C.	Ext. T.—Temp. of A. °C.
8.30 a.m.	27 (room)	21·5	24	5·5
11.30 a.m.	36·5	31	35	5·5
2.30 p.m.	36·5	30·5	36	6

It will be noted that the tests were made under varying, and all of them severe, conditions, and that throughout the whole of the experiment an average difference of 5·8°C. was maintained. A noteworthy fact is that this average increases with rise of external temperature, so that the action of the apparatus appears to be compensatory, that is, its

effectiveness increases as the external heat becomes greater. This is evidenced by the following table:—

External Temperature. °C.	Diff. maintained by Carrier. °C.	Other Conditions.
37	11·5	Open air direct to sun's rays.
36·5	6	Hot, humid atmosphere.
31·7	5·5	Ditto.
27	4·5	Warm, shady position.
25·5	4	Ditto.
25·5	3·5	Ditto.

The most severe test is undoubtedly No. 3, and it is to be noted that, even under such conditions, the carrier was able to maintain a difference in temperature of 5° C.


Two bands of minute perforations to allow passage of water into the absorbent covering
Absorbent material such as lamp wick is made of
Thin copper or zinc cylinder
Air chamber
RESERVOIR for WATER, ICE OR SPIRIT
VACCINE PHIAL
Cork
Metal springs
Metal partition
Thick perforated zinc box with perforations at each end

LIST OF FELLOWS.

The following have been duly elected Fellows of the Society :—

Arthur William Bacot, Lister Institute of Preventive Medicine, London.

W. A. F. Balfour-Browne, M.A. (Oxon. et Cantab.), F.R.S.E., F.Z.S., F.E.S., Lecturer in Zoology (Univ. Cambridge), Barrister-at-Law.

Sarojini Nath Bardhan, B.A., L.M.S., D.T.M., Rai Sahib, Government Pathological Laboratory, Sepoy Lines, Singapore.

Abd El Aziz Birdary (Graduate, American Univ., Beirut), Cairo.

Henry Francis Carter, Government Malariologist, Ceylon.

Major Herbert St. Maur Carter, D.S.O., M.D., B.Ch., B.A.O. (Univ. Dublin), R.A.M.C., Bombay.

Col. William Wesley Clemesha, C.I.E., M.D., D.P.H., I.M.S., London.

Surgeon-Commander Shildon Francis Dudley, O.B.E., M.R.C.S., L.R.C.P., D.P.H., D.T.M., M.D., B.S. (Lond.), R.N. College, Greenwich.

Frank Grenier, M.D. (Edin.), D.T.M. & H. (Cantab.), Ceylon.

J. C. N. Harris, B.A. (Cantab), M.R.C.S., L.R.C.P., Khartoum, Sudan.

Roy Mervyn Humphreys, B.M., B.Ch. (Oxon.), Medical Dept., Sudan Govt., Khartoum.

John William Jackson, M.B., C.M. (Glasgow), London, late of Shanghai.

William Alford Lamborn, M.R.C.S., L.R.C.P., Zomba, Nyasaland.

Andrew Henry Mitchell, M.B., Ch.B. (Aberdeen Univ.), Colonial Medical Service, Kenya.

W. Marshall Philip, M.B., C.M., D.P.H., M.O.H., Colombo, Ceylon.

C. Llewellyn Howard Tripp, M.R.C.S., L.R.C.P. (Lond.), L.S.A., Exeter.

MOVEMENTS OF FELLOWS.

The following Fellows have notified the Secretaries that they are at present in England :—

Major C. H. Bowle-Evans, C.M.G., India.
W. J. Bruce, M.R.C.S., Gold Coast.
Donald W. Carr, M.D., Persia.
F. Charlesworth, M.D.
H. F. Conyngham, L.R.C.P., Borneo.
Major F. W. Cragg, M.D., I.M.S., India.
J. B. Davey, M.B., M.R.C.S., Tanganyika.
H. Lyndhurst Duke, B.A., B.C., M.D., Uganda.
Colonel F. W. King, F.R.C.S., India.
J. Scott Macfie, M.B., Gold Coast.
P. A. Maplestone, D.S.O., Australia.
Major W. E. Marshall, R.A.M.C., Arabia.
F. W. O'Connor, M.R.C.S.
W. H. Peacock, M.B., M.R.C.S., Sierra Leone.
A. Pearson, M.B.
Arthur Pickels, M.B., B.S., Gold Coast.
H. S. Hollenbeck, M.D., Angola, is at present in U.S.A.

EDITORIAL NOTICES.

The Editor of the TRANSACTIONS will be pleased to receive short papers to be included under the heading of "Notes and Comments" or "Questions," in addition to longer papers on subjects of Tropical interest, which may be offered for presentation at meetings of the Society. He will also be glad to receive books for review.

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